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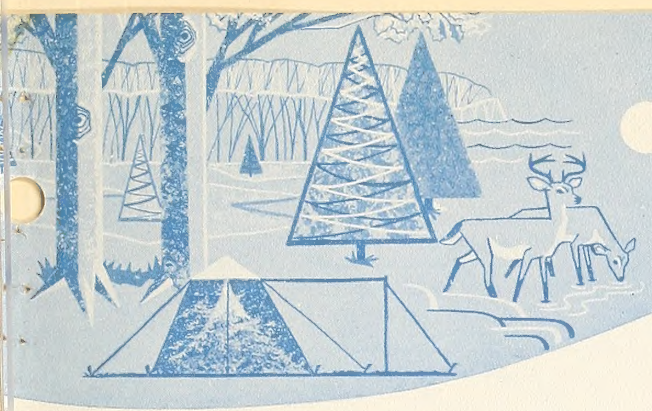

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Diameters and Numbers of Trees in Red Pine Stands Are Greatly Affected by Density, Age, and Site

Tree diameter and number of trees per acre greatly influence the value and kind of products produced from red pine stands. Until recently, predictions of diameters and numbers of trees per acre have not been available for intensively managed red pine stands. They have now been computed for a range of management alternatives. These computations show that diameters and numbers of trees produced are affected by site, and can be controlled through the choice of initial spacing in new plantations and thinning intensity in existing stands.

In this Research Note, the diameter of the tree of average basal area is used as the average stand diameter. This can be computed from the following formula if the basal area and number of trees per acre are known:

$$D^2 = (BA/N)\,(4/\pi)\,(144)$$

where D = average stand diameter
BA = basal area in sq. ft. per acre
N = number of trees per acre

A current study by the junior author has estimated basal areas for red pine plantations with given numbers of trees per acre at age 35 over a range of sites. A recent study has provided basal area growth and yield estimates by basal area density, age, and site for stands over 35 years of age.[1] These basal area estimates were used in a method developed by the senior author to predict the number of trees per acre left after thinning to an assigned basal area at age 35 and every 10 years thereafter. It was assumed that the stand is cut from above and below so that the proportion of trees cut per acre at each thinning is the same as the proportion of basal area cut. This assures that the diameter of the tree of average basal area is not changed by the thinning. It was further assumed that no trees die between thinnings.

From these estimated number of trees and known basal areas after thinning every 10 years, the diameter of the tree of average basal area was computed. For want of better information, the growth and yield data from regularly thinned stands of a natural origin are assumed to apply to regularly thinned plantations as well.

To illustrate how much diameters and numbers of trees per acre can vary in periodically thinned red pine stands, three stand densities and two sites have been selected as examples (table 1).

Many other combinations of initial stocking (the number of trees per acre before thinning at age 35) and basal area density after thinning could be used. However, it was not possible to consider separately the effect of initial stocking and basal area density in this Note. Instead, the two measures of stand density are presented jointly. The examples were deliberately chosen to show how density extremes can affect future diameters and numbers of trees: low initial stocking thinned to a low basal area density; medium initial stocking thinned to a medium basal area

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[1] *Buckman, Robert E. Growth and yield of red pine in Minnesota. U. S. Dept. Agr. Bul. 1272, 50 pp., illus. 1962.*

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TABLE 1. — *Number of trees and basal area per acre for three stand densities, before and after thinning*

Stand density	Basal area left after each thinning	Before thinning at age 35		
		Trees	Basal area at site index	
			50	60
	Square feet	*Number*	*Square feet*	
Low	90	800	165	180
Medium	120	1,200	180	195
High	150	1,600	195	210

density; and high initial stocking thinned to a high basal area density. These approximate the range of current stand density management practices in the Lake States.

As figure 1 shows, by keeping a stand at a low rather than a high density, the forest manager can produce trees of a given diameter at an earlier age, or he can produce larger diameter trees at any given age. For example, if he wishes to grow 15-inch trees on site-index-60 land, he will get them at age 75 with low-density management, at age 105 with medium-density management, and at age 165 with high-density management. Or, at age 95 he will have 20-inch, 13-inch, or 10-inch trees depending upon whether he chooses to manage his stands at a low, medium, or high density. It also follows that at a given age the trees removed in thinning will be larger in low-density stands than in high.

Larger diameter trees can be grown at earlier ages on better sites. For example, by age 95 with low-density management, site-index-60 land will produce trees averaging 3½ inches larger than those on site-index-50 land. This difference in diameters is especially large at older ages and low densities. Of course the trees will also be taller on the better sites, thus increasing the difference in individual tree volume.

The combined influence of stand density and site on diameter growth rates is large (table 2). In low-density stands on site-index-60 land, diameter growth is rapid, with never more than 10 annual rings per inch after age 45. At the other extreme, in high-density

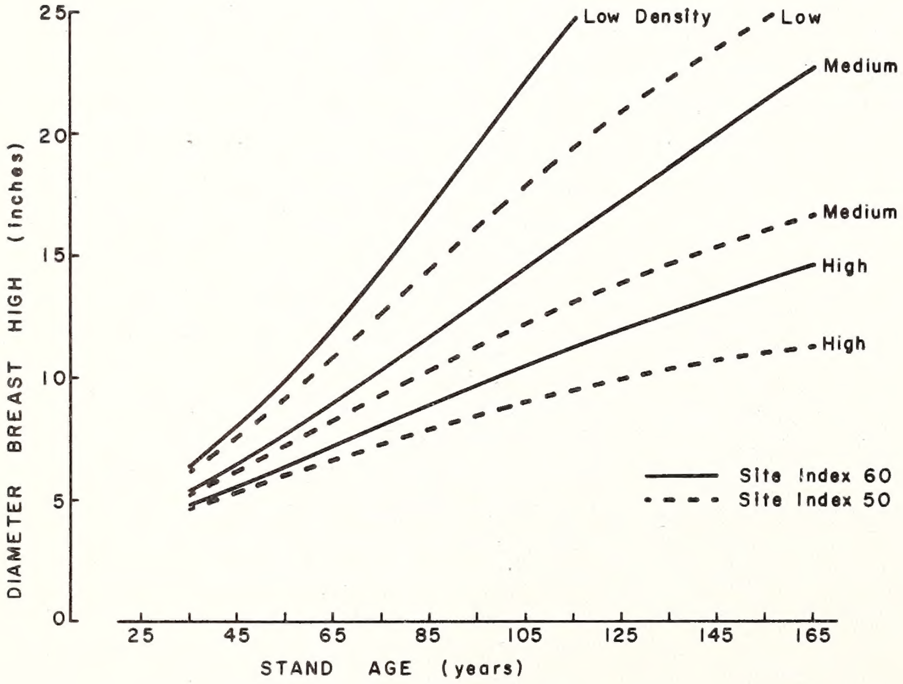

FIGURE 1. — Expected diameter of the tree of average basal area in red pine stands managed at low, medium, and high densities.

TABLE 2. — *Average number of rings per inch at d.b.h. for red pine thinned to the indicated basal area every 10 years*

Stand age (years)	Site index 50			Site index 60		
	Square feet of basal area per acre			Square feet of basal area per acre		
	90	120	150	90	120	150
35 - 45	14	22	29	12	18	29
45 - 55	12	20	29	10	17	25
55 - 65	12	18	33	10	15	25
65 - 75	11	20	33	8	15	25
75 - 85	11	20	33	8	14	22
85 - 95	12	20	33	8	14	25
95 - 105	12	22	40	7	14	25
105 - 115	12	22	40	8	14	29
115 - 125	14	25	50	(1)	14	29
125 - 135	14	25	50	—	14	29
135 - 145	17	29	50	—	15	29
145 - 155	17	33	67	—	14	33
155 - 165	(1)	33	67	—	14	29

[1] *Stand clearcut at beginning of period because of low number of trees per acre.*

TABLE 3. — *Number of red pine trees per acre after thinning to the indicated basal area every 10 years*

Stand age (years)	Site index 50			Site index 60		
	Square feet of basal area per acre			Square feet of basal area per acre		
	90	120	150	90	120	150
35 (before thinning)	800	1,200	1,600	800	1,200	1,600
35	434	794	1,226	405	744	1,156
45	284	570	946	253	515	865
55	194	422	749	165	368	665
65	138	323	610	112	271	525
75	102	255	508	78	205	424
85	79	207	433	57	160	350
95	63	173	378	43	128	294
105	51	147	335	33	104	252
115	43	128	303	(1)	87	220
125	38	114	277	—	74	194
135	33	102	257	—	63	174
145	30	93	241	—	55	156
155	(1)	86	227	—	48	142

[1] *Stand clearcut at this age because of low number of trees per acre.*

stands on site-index-50 land, growth rates are very low at older ages, with never fewer than 40 annual rings per inch after age 95.

The advantages of getting larger diameters at earlier ages from low-density management must be weighed against the smaller number of trees available for harvest (table 3). At any age there are fewer trees in low-density stands than in high. It is also true that in low-density stands fewer trees per acre are available for harvest when they reach a given size (compare table 3 and figure 1).

To illustrate this last point, the forester growing 15-inch red pine on site index 60 will have available for final harvest either 112 trees at age 75, 128 at age 105, or 142 at age 165, depending upon whether he carries his stand at a low, medium, or high density.

The number of trees per acre is also affected by site. On better sites there will be fewer trees at any given age and density level than on poorer sites. Basal area growth rates are higher on better sites, so a larger proportion of the trees must be cut each time the stand is thinned to the assigned basal area level.

The examples given indicate that foresters can control the diameters and numbers of trees produced at a given age by varying the initial stocking and thinning intensity in red pine stands on different sites. A more detailed analysis now being completed will predict diameters and numbers of trees for any combination of initial stocking, stand basal area density, age, and site index over a wide range. With this information the forest manager will be in a better position to grow the number and kinds of red pine trees that will best satisfy his objectives.

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